

# Experimental Investigation of the Near Wake of a Pick-up Truck

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## ABSTRACT

The results of an experimental investigation of the flow over a pickup truck are presented. The main objectives of the study are to gain a better understanding of the flow structure in near wake region, and to obtain a detailed quantitative data set for validation of numerical simulations of this flow. Experiments were conducted at moderate Reynolds numbers ( $\sim 3 \times 10^5$ ) in the open return tunnel at the University of Michigan. Measured quantities include: the mean pressure on the symmetry plane, unsteady pressure in the bed, and Particle Image Velocimetry (PIV) measurements of the flow in the near wake. The unsteady pressure results show that pressure fluctuations in the forward section of the bed are small and increase significantly at the edge of the tailgate. Pressure fluctuation spectra at the edge of the tailgate show a spectral peak at a Strouhal number of 0.07 and large energy content at very low frequency. The velocity field measurements in the symmetry plane show that shear layers form at the top of the cab and the underbody flow region. The cab shear layer evolves more slowly than the underbody flow shear layer and does not interact strongly with the tailgate for the present geometry. Behind the tailgate there is no recirculating flow region in the symmetry plane believed to be due to downwash from streamwise vorticity in the near wake. There are small recirculating regions on the sides of the tailgate symmetry plane extending approximately one tailgate height downstream.

## INTRODUCTION

Pickup trucks are one of the more popular vehicle geometries in use today yet it has received very little attention in the car aerodynamics literature. The aerodynamics of pickup trucks is more complex than other open bed trucks because the short length of the bed can result in interaction of the bed walls and tailgate with the separated shear layer formed at the edge of the cab. The complexity of the flow makes drag prediction tools, including CFD based methods, unreliable. The main goal of the present research is to gain a better understanding of pickup truck aerodynamics using

detailed flow field measurements that can also be used for validation of computational models.

The aerodynamics of road vehicles has frequently been studied in simplified geometries to separate the effect of various components on aerodynamic drag and on near wake flow dynamics. A review of early work in this area can be found in Hucho.<sup>1</sup> Particularly relevant to the present work are the investigations by Balkanyi and co-workers<sup>2-4</sup> on the effects of drag reducing devices on the near wake flow. PIV measurements and unsteady pressure measurements show that the near wake turbulence structure is modified by the drag reducing devices. The turbulence intensity is reduced while the shape and downstream extent of the recirculating flow region is not strongly affected. In several configurations, a peak in the pressure fluctuation power spectra is found at a Strouhal number based on model width of 0.1. This peak is not present in cases with larger drag reduction. These results are consistent with the results of full scale tests of a tractor trailer vehicle by Lanser *et al*.<sup>5</sup> Duell and George<sup>6</sup> report unsteady flow effects in the near wake of a three-dimensional bluff body with a blunt base similar to the one used by Balkanyi and co-workers. They differentiate between unsteady effects in the separated shear layer at the edge of the body and the closed recirculating flow region. The initial development of the separated shear layer is dominated by vortex roll-up and merging processes with a characteristic Strouhal number  $\sim 1$ . In contrast the wake pumping associated with unsteadiness of the recirculating flow region has a characteristic Strouhal number  $\sim 0.07$ . Recently Leitz *et al*<sup>7</sup> have reported results of numerical simulations and experiments of the flow behind the tailgate of a pickup truck. An important difference between the pickup truck flow and the simplified geometries discussed earlier are the streamwise vortices that form in the near wake of the pickup truck.

In this paper we present results of an experimental program that aims at gaining a better understanding of the flow in the near wake of a pickup truck. We use the wind tunnel PIV system developed by Balkanyi *et al*<sup>2</sup> to document the structure of the turbulent flow in the near